PATENT COOPERATION TREATY

PCT

REC'D 01 JUN 2005
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 35010/144WO	**FOR FURTHER ACTION** See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US 03/03564	International filing date *(day/month/year)* 05.02.2003	Priority date *(day/month/year)* 05.02.2003
International Patent Classification (IPC) or both national classification and IPC G01N9/00		
Applicant MICRO MOTION, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the opinion
   II ☐ Priority
   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☐ Lack of unity of invention
   V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   VI ☐ Certain documents cited
   VII ☐ Certain defects in the international application
   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
24.08.2004	02.06.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Hocquet, A Telephone No. +31 70 340-2928

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-3, 6-14	as originally filed
4, 5	received on 27.08.2004 with letter of 24.08.2004

Claims, Numbers

1-19	received on 27.08.2004 with letter of 24.08.2004

Drawings, Sheets

1/5-5/5	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

☐ the description,	pages:	
☒ the claims,	Nos.:	20-21
☐ the drawings,	sheets:	

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1-19
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-19
Industrial applicability (IA)	Yes:	Claims	1-19
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following document/s/:

D1: US 2002/093875 A1 (RONDEAU ET AL) 18 July 2002

D2: EP-A-0 253 504 (SCHLUMBERGER) 20 January 1988

D3: KALOTAY P: "Density and viscosity monitoring systems using Coriolis flow meters" ISA TRANSACTIONS, INSTRUMENT SOCIETY OF AMERICA. PITTSBURGH, US, vol. 38, no. 4, 25 November 1999 (1999-11-25), pages 303-310, XP004244796 ISSN: 0019-0578

1 The subject-matter of claim 1 is not clear. Claim 1 relates to a system, which is a physical entity, but tries to define the physical entity by the activities it can perform by the repeated use of the expression 'configured to...[measure ... transmit... receive...determine]'.

2.1 The above lack of clarity notwithstanding, the present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 does not involve an inventive step in the sense of Article 33(3) PCT. The document D1 is regarded as being the closest prior art to the subject-matter of claim 1 and discloses in its figure 1 and its paragraph 3 as prior art a measurement system comprising a flow meter (26) and a control system. Figure 1 is not directed at a fracture fluid (but a cement) but in its paragraph 38, D1 mentions that the mixing apparatus and method can be applied to such a fluid, and the words 'proppant', 'base fluid' and 'fracture fluid' are used herein below as corresponding to 'solid materials', 'mix water' and 'slurry'. The flow meter is 'configured to' measure a density of a base fluid (mix water 10) flowing through said flow meter to generate a base fluid density measurement (valve 20 closed so that only the mix water circulates in mixer 14, tub 16 and recirculation pump 22), transmit said base fluid density measurement, measure a density of a fracture fluid (slurry circulating in loop 22 when the valve 20 is open), flowing through said flow meter 26 to generate a fracture fluid density measurement, wherein said fracture fluid comprises a mixture of said base fluid and a proppant (solid material in can 18), and transmit said fracture fluid density measurement; and said control system being configured to receive said base fluid density measurement and said

fracture fluid density measurement, and determine an amount of said proppant in said fracture fluid based on said base fluid density measurement, said fracture fluid density measurement, and a density of said proppant. D1 mentions the use of Coriolis flow meters as typical (paragraph 3) and indicates later in the context of the transposition to fracturing fluids (paragraph 38) that Coriolis meters have limitations in respect of flow rate.

2.2 The apparatus of figure 1 is 'configured' to measure the density of the base fluid. When this base fluid is pure water, the skilled person may consider that 'the liquid phase is constant' (D1, par.3) and skip this step of the method of use. But it would be obvious to the skilled person, that when the density of the base fluid may vary, or is not known a priori, its measurement is needed to calculate the amount of proppant/solid material in the slurry/fracture fluid.

3 The subject-matter of claim 1 therefore differs from D1 in that the measurement is performed in slip-stream.

4 The problem to be solved by the present invention may therefore be regarded as solving the problem of flow rates so that Coriolis meters can be used (see description page 2 lines 33-34, 'First ..') . As mentioned above, D1 indicates already the problem in its paragraph 38.

5 The solution proposed in claim 1 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the following reasons: It is known from D3 to use Coriolis densimeters in slipstream (D3, par. 2.2) for computing the solid content of a slurry (D3, 2.4) and the same document D3 mentions as a main advantage of slipstream arrangement the capacity to choose almost any flow rate (par. 3.3).

6 The feature of claim 2 (a straight tube Coriolis flow meter) solves a second problem different of the problem mentioned above in paragraph 4 (see description, page 3, lines 1-4, 'secondly ...'). But this second problem (erosion of curved tubes due to abrasive solids) is known (D2, p 2, l 9-12) as well as its solution (using a straight-tube: D2, p 2, l 13-25). The solution proposed in claim 2 of the present application cannot therefore be considered as involving an inventive step (Article 33(3) PCT) .

7 The features of claim 3 makes explicit the connections which result from the use of a slip stream (by-pass) arrangement for the density meter. The reasoning of above paragraphs 3-5 apply to that claim.

8 The expression 'to determine the density of said proppant' (claim 4,. claim 11) is not supported by the description which mentions (page 9, lines 27-29) that the control system 'receives' it.

9 The reasoning of above paragraphs applies, mutatis mutandis, to the subject-matter of the corresponding independent claim 11 and dependent claims 12,13 , which therefore are also considered not inventive.

10 Dependent claims 5-10 and 14-19 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, because come within the scope of the customary practice followed by persons skilled in the art when designing a measurement system.

said Coriolis flow meter being configured to measure a density of a base fluid flowing through said Coriolis flow meter to generate a base fluid density measurement, transmit said base fluid density measurement, receive a slip stream of a fracture fluid to measure a density of said fracture fluid, measure the density of the fracture fluid flowing through said Coriolis flow meter to generate a fracture fluid density measurement, wherein said fracture fluid comprises a mixture of said base fluid and a proppant, and transmit said fracture fluid density measurement; and

said control system being configured to receive said base fluid density measurement and said fracture fluid density measurement, and determine an amount of said proppant in said fracture fluid based on said base fluid density measurement, said fracture fluid density measurement, and a density of said proppant.

Preferably, the Coriolis flow meter comprises a straight tube Coriolis flow meter.

Preferably, the measurement system further comprises:

a first tube having a first end configured to connect to an input of said Coriolis flow meter and having a second end configured to connect to a discharge of a tank; and

a second tube having a first end configured to connect to an output of said Coriolis flow meter and having a second end configured to connect to said tank;

wherein said first tube is configured to receive a slip stream of material from said discharge of said tank, said slip stream travels through said first tube, through said Coriolis flow meter, through said second tube, and back into said tank.

Preferably, the control system is configured to determine said density of said proppant.

Preferably, the control system comprises a display system configured to provide said amount of said proppant to a user.

Preferably, the control system comprises an auxiliary interface configured to transmit a signal representing said amount of said proppant to an auxiliary system.

Preferably, the control system comprises a user interface configured to receive said density of said proppant entered by a user.

Preferably, the control system is configured to:

calculate a velocity of said fracture fluid;

determine if said velocity of said fracture fluid exceeds a threshold; and

provide an indication if said velocity of said fracture fluid exceeds said threshold.

Preferably, the control system is configured to:

calculate an average density of said base fluid based on a plurality of density measurements of said base fluid by said Coriolis flow meter; and

determine said amount of said proppant in said fracture fluid based on said average density of said base fluid, said fracture fluid density measurement, and said density of said proppant.

Preferably, the Coriolis flow meter is configured to measure a mass flow rate of said fracture fluid, and provide at least one of said mass flow rate of said fracture fluid and a drive gain of said Coriolis flow meter to said control system; and

said control system is configured to provide at least one of said mass flow rate of said fracture fluid and said drive gain of said Coriolis flow meter to a user.

Another aspect of the invention comprises a method of measuring an amount of proppant in a fracture fluid, said method comprising the step of:

determining a density of said proppant;

said method characterized by the steps of:

measuring a density of a base fluid with a Coriolis flow meter to generate a base fluid density measurement;

receiving a slip stream of a fracture fluid into said Coriolis flow meter to measure a density of said fracture fluid;

measuring the density of the fracture fluid with said Coriolis flow meter to generate a fracture fluid density measurement, wherein said fracture fluid comprises a mixture of said base fluid and a proppant; and

determining an amount of said proppant in said fracture fluid based on said base fluid density measurement, said fracture fluid density measurement, and said density of said proppant.

Preferably, the step of measuring a density of a fracture fluid with said Coriolis flow meter comprises:

measuring said density of said fracture fluid with a straight tube Coriolis flow meter.

Preferably, the method further comprises the steps of:

connecting a first end of a first tube to an input of said Coriolis flow meter;

connecting a second end of said first tube to a discharge of a tank;

What is claimed is:

1. A measurement system (200) comprising a Coriolis flow meter (222) and a control system (224),

said measurement system characterized by:

said Coriolis flow meter being configured to measure a density of a base fluid (250) flowing through said Coriolis flow meter to generate a base fluid density measurement, transmit said base fluid density measurement, receive a slip stream (280) of a fracture fluid (202) to measure a density of said fracture fluid, measure the density of the fracture fluid (202) flowing through said Coriolis flow meter to generate a fracture fluid density measurement, wherein said fracture fluid comprises a mixture of said base fluid and a proppant (252), and transmit said fracture fluid density measurement; and

said control system being configured to receive said base fluid density measurement and said fracture fluid density measurement, and determine an amount of said proppant in said fracture fluid based on said base fluid density measurement, said fracture fluid density measurement, and a density of said proppant.

2. The measurement system (200) of claim 1 wherein said Coriolis flow meter (222) comprises a straight tube Coriolis flow meter (400).

3. The measurement system (200) of claim 1 further comprising:

a first tube (226) having a first end (271) configured to connect to an input of said Coriolis flow meter (222) and having a second end (272) configured to connect to a discharge (218) of a tank (210); and

a second tube (227) having a first end (281) configured to connect to an output of said Coriolis flow meter and having a second end (282) configured to connect to said tank;

wherein said first tube is configured to receive a slip stream (280) of material from said discharge of said tank, said slip stream travels through said first tube, through said Coriolis flow meter, through said second tube, and back into said tank.

4. The measurement system (200) of claim 1 wherein said control system (224) is configured to determine said density of said proppant (252).

5. The measurement system (200) of claim 1 wherein said control system (224) comprises: a display system (302) configured to provide said amount of said proppant (252) to a user.

6. The measurement system (200) of claim 1 wherein said control system (224) comprises: an auxiliary interface (306) configured to transmit a signal representing said amount of said proppant (252) to an auxiliary system.

7. The measurement system (200) of claim 1 wherein said control system (224) comprises: a user interface (304) configured to receive said density of said proppant (252) entered by a user.

8. The measurement system (200) of claim 1 wherein said control system (224) is configured to:

calculate a velocity of said fracture fluid (202);

determine if said velocity of said fracture fluid exceeds a threshold; and

provide an indication if said velocity of said fracture fluid exceeds said threshold.

9. The measurement system (200) of claim 1 wherein said control system (224) is configured to:

calculate an average density of said base fluid (250) based on a plurality of density measurements of said base fluid by said Coriolis flow meter (222); and

determine said amount of said proppant (252) in said fracture fluid (202) based on said average density of said base fluid, said fracture fluid density measurement, and said density of said proppant.

10. The measurement system (200) of claim 1 wherein:

said Coriolis flow meter (222) is configured to measure a mass flow rate of said fracture fluid (202), and provide at least one of said mass flow rate of said fracture fluid and a drive gain of said Coriolis flow meter to said control system (224); and

said control system is configured to provide at least one of said mass flow rate of said fracture fluid and said drive gain of said Coriolis flow meter to a user.

11. A method of measuring an amount of proppant in a fracture fluid, said method comprising the step of:

determining a density of said proppant;

said method characterized by the steps of:

measuring a density of a base fluid (250) with a Coriolis flow meter (222) to generate a base fluid density measurement;

receiving a slip stream (280) of a fracture fluid into said Coriolis flow meter to measure a density of said fracture fluid;

measuring the density of the fracture fluid (202) with said Coriolis flow meter to generate a fracture fluid density measurement, wherein said fracture fluid comprises a mixture of said base fluid and a proppant (252); and

determining an amount of said proppant in said fracture fluid based on said base fluid density measurement, said fracture fluid density measurement, and said density of said proppant.

12. The method of claim 11 wherein the step of measuring a density of a fracture fluid (202) with said Coriolis flow meter (222) comprises:

measuring said density of said fracture fluid with a straight tube Coriolis flow meter (400).

13. The method of claim 11 further comprising the steps of:

connecting a first end (271) of a first tube (226) to an input of said Coriolis flow meter (222);

connecting a second end (272) of said first tube (226) to a discharge (218) of a tank (210);

connecting a first end (281) of a second tube (227) to an output of said Coriolis flow meter; and

connecting a second end (282) of said second tube (227) to said tank;

wherein said first tube receives a slip stream (280) of material from said discharge of said tank, said slip stream travels through said first tube, through said Coriolis flow meter, through said second tube, and back into said tank.

14. The method of claim 11 further comprising the step of:

providing said amount of said proppant (252) to a user.

15. The method of claim 11 further comprising the step of:
transmitting a signal representing said amount of said proppant (252) to an auxiliary system.

16. The method of claim 11 further comprising the step of:
receiving said density of said proppant (252) from a user.

17. The method of claim 11 further comprising the steps of:
calculating a velocity of said fracture fluid (202);
determining if said velocity of said fracture fluid exceeds a threshold; and
providing an indication if said velocity of said fracture fluid exceeds said threshold.

18. The method of claim 11 further comprising the steps of:
calculating an average density of said base fluid (250) based on a plurality of density measurements of said base fluid by said Coriolis flow meter (222); and
determining said amount of said proppant (252) in said fracture fluid (202) based on said average density of said base fluid, said fracture fluid density measurement, and said density of said proppant.

19. The method of claim 11 further comprising the steps of:
measuring a mass flow rate of said fracture fluid (202) with said Coriolis flow meter (222); and
providing at least one of said mass flow rate of said fracture fluid and a drive gain of said Coriolis flow meter to a user.